



National Aeronautics and Space Administration



## Independent Verification & Validation Program



*Assuring excellence in safety and mission critical software since 1993*



## IV&V Program



- Established 1993
- Staff of ~250 personnel
  - ~45 Civil Servants
  - **TASC** contractors (prime)
  - Other support contractors
- ISO – 9001 Certified





# IV&V Program Services



- Life-cycle IV&V
- Independent Assessments
- Safety & Mission Assurance Support
  - Common support infrastructure for assuring core Software Assurance functions across the Agency
  - **Cybersecurity & Information Assurance**
  - **Secure Coding**
- Software Assurance Research Program (SARP)
- **Jon McBride Software Testing And Research (JSTAR) Laboratory**
  - **Independent Test Capability (ITC)**
  - **Robotics**
  - **Cybersecurity Lab**
- STEM Outreach







# Sample of IV&V's History



- **All High Priority NASA Missions:**
  - Human Exploration – SLS, MPCV, GSDO, Shuttle, Station
  - Commercial Crew – Boeing, SpaceX
  - James Webb Space Telescope
  - MAVEN (in the news currently, just reached performed Mars Deep Dip)
  - Many more ....
- **FAA**
  - Independent assessment of a contract management system
- **New York City 911 – ECTP**
  - Systems Engineering IV&V effort worked in collaboration with NYC Mayors office to provide assurance that the emergency communications program
- **Jet Propulsion Laboratory**
  - Performing a Blue Team Vulnerability Assessment against mission threads
- **Department of Energy**
  - Drafting agreement for independent assessment related to information assurance
- **Department of Veterans Affairs**
  - Currently drafting agreements to perform systems, software, and security IV&V activities



# JSTAR & Independent Test Capability Team



- ✓ Create specialized group for simulation and test

**ITC team formed in 2009**

## ITC Charter

The NASA IV&V Program's Independent Test Capability (ITC) is responsible for acquiring, developing and maintaining adaptable test environments. These test environments enable the NASA's IV&V Program to perform dynamic analysis of software behaviors for multiple NASA missions.

The ITC team is the expert in simulation and the IV&V project teams are experts in the systems.

IV&V project teams utilize the solutions developed by the ITC team within the JSTAR laboratory.

- ✓ Provide infrastructure to support efforts

**JSTAR Lab Built in 2010**



## ✓ IV&V Projects Utilized JSTAR

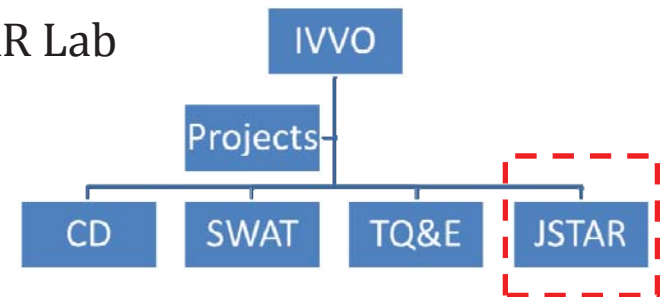
- Autonomous Flight Safety System (AFSS)
- Global Precipitation Measurement (GPM)
- International Space Station (ISS)
- James Webb Space Telescope (JWST)
- Juno
- Mars Atmosphere and Volatile Evolution (MAVEN)
- Multi-Purpose Crew Vehicle (MPCV)
- Space Launch Systems (SLS)
- ...



# ITC and JSTAR

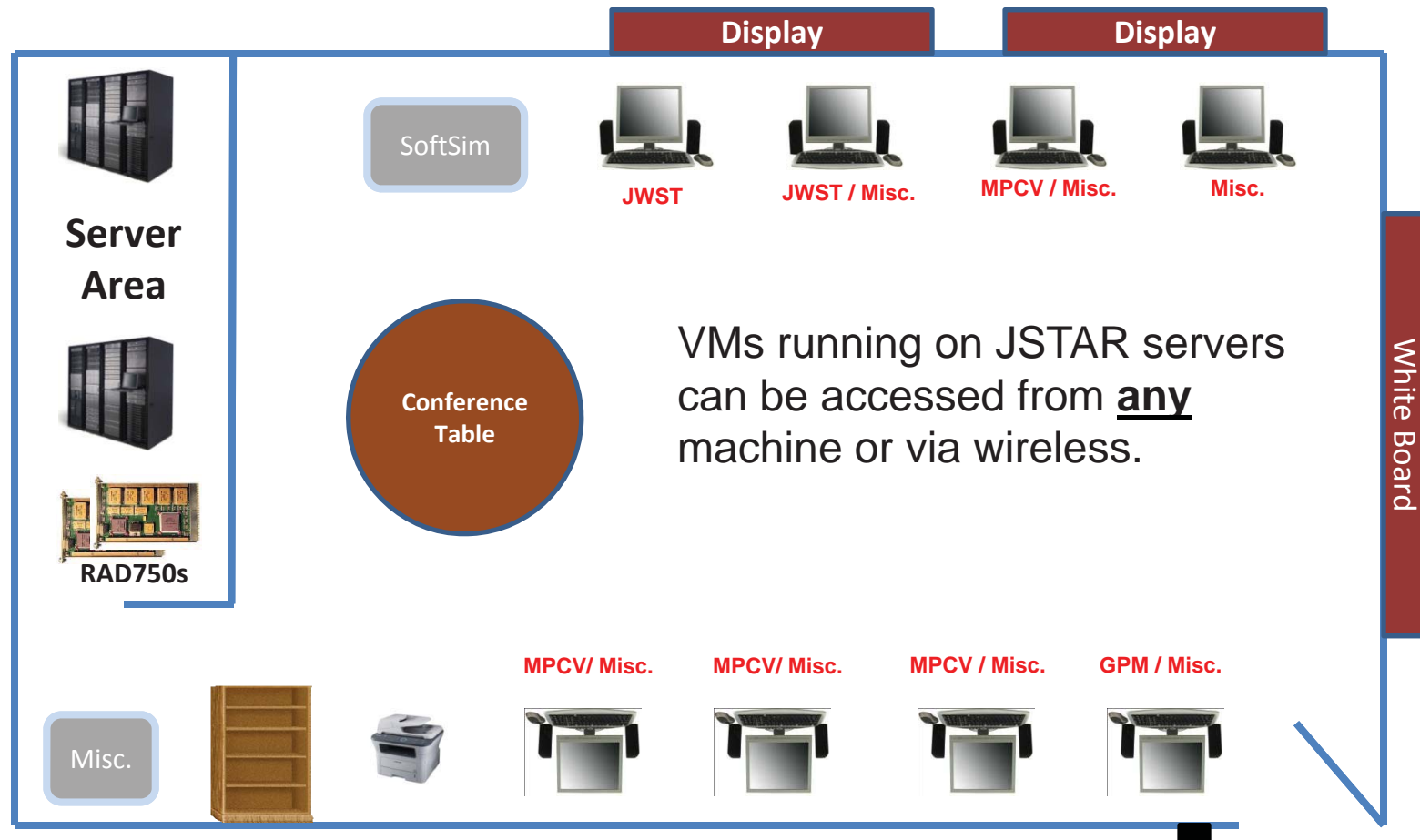


- Independent Test Capability (ITC) team was formed in 2009
  - Develop, maintain, and operate adaptable test environments for the IV&V Program that enables the dynamic analysis of software behaviors for multiple NASA missions
    - These capabilities are deployed within the JSTAR Lab
  - ITC team resides within JSTAR group
  - JSTAR Lab currently spans two physical rooms [B2-215 and B1 -226]
    - Houses tools, provides area for capability development (Robotics, R&D, OC-Flight-1, etc.), and resources for performing dynamic analysis
    - Resources are managed by the JSTAR Lab Manager (Brandon Bailey)





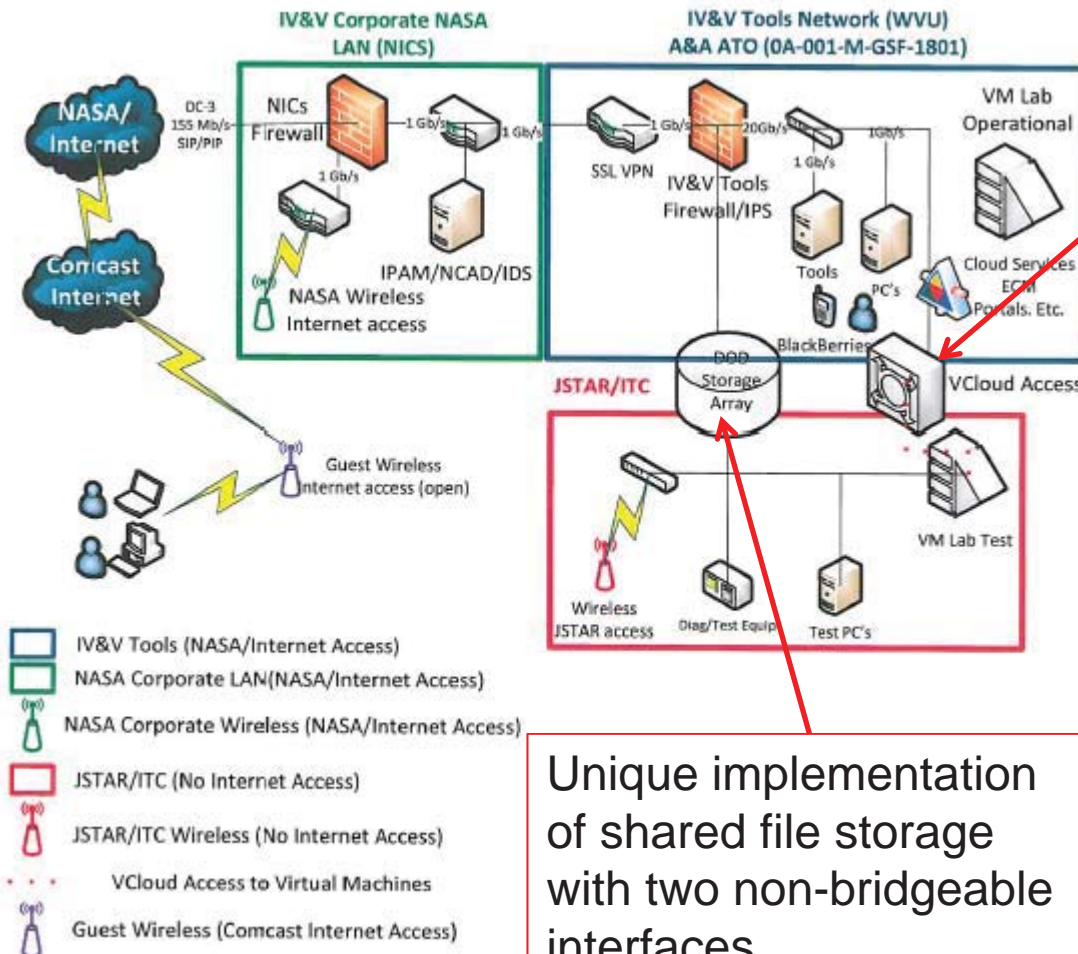
# JSTAR Layout



Single Location – Multiple Preconfigured Tools and Test Environments



# Network Configuration



Unique usage of the vCloud product allowing for external access to isolated lab.

The JSTAR Lab is **NOT** connected to IVV network.  
All computers in the lab are connected on an internal JSTAR network

Unique implementation of shared file storage with two non-bridgeable interfaces.





# Work Performed in JSTAR

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- Jon McBride Software Testing And Research (JSTAR) Laboratory
  - **Independent Test Capability (ITC)**
    - **Acquire, develop and maintain adaptable test environments**
  - Robotics
    - Mostly small scale research oriented to train IV&V practitioner
  - Cybersecurity Lab
    - Mission Vulnerability Assessments, Penetration Testing Training, etc.
  - Cubesat Development



# Test System Approaches



- The following four approaches have been utilized to provide test systems to the NASA IV&V Program
  1. Acquire a copy of a development project's test system {MAVEN, MPCV, ISS, O-REx, GSDO, SLS\*}
  2. Develop software-only test system in-house {JWST, GPM, JUNO, DSCOVR, InSight, SDLS Prototype}
  3. Setup a Hardware-in-the-Loop Test Environment {AFSS, JWST}
  4. Setup Remote Access and/or Physical Access to Test Systems {MAVEN, SMAP}

\* SLS will have custom development in addition to provided simulation



# ITC Current Work



- Projects Overview
  - International Space Station (ISS)
  - **JWST Integrated Simulation and Test (JIST)**
  - Multipurpose Crew Vehicle (MPCV)
  - Space Launch Systems (SLS)
  - Ground Systems Development and Operations (GSDO)
  - Osiris-Rex (O-REx)
- NASA Operational Simulator (NOS)
  - Reusable Hardware Models
  - Custom Middleware with Interception Capability
- System Test Automation
- Hardware Modeling
- Cube Sat
- CCSDS SDLS Prototype Development/Testing



# 2012 Software of the Year Competition



**Configurable on a single USB stick**

"GO-SIM provides a solution to reducing the cost of deploying Goddard Dynamic Simulator (GDS) to mission subsystem teams and test teams... GO-SIM also yields significant reuse potential for future in-house GSFC missions by incorporation of the GDS."

Stephen Leake  
GSFC GDS Product Development Lead

## *GO-SIM Simulation Software Receives Honorable Mention at 2012 Agency-Wide Software of the Year Competition*

High fidelity simulator with no hardware dependencies

Simulation of operational spacecraft and ground system

Controlled execution of simulation model and processor states (start, stop, pause, resume)

Architecture supports dynamic addition of external custom spacecraft components to simulation environment

Fault injection of spacecraft hardware and measurements, software and environmental variables to test flight software management responses

Step-wise execution of flight software in controlled, repeatable manner

Execute mission scenarios and characterize timing behavior, memory usage, and CPU utilization





# Specialized Hardware in the JSTAR Lab



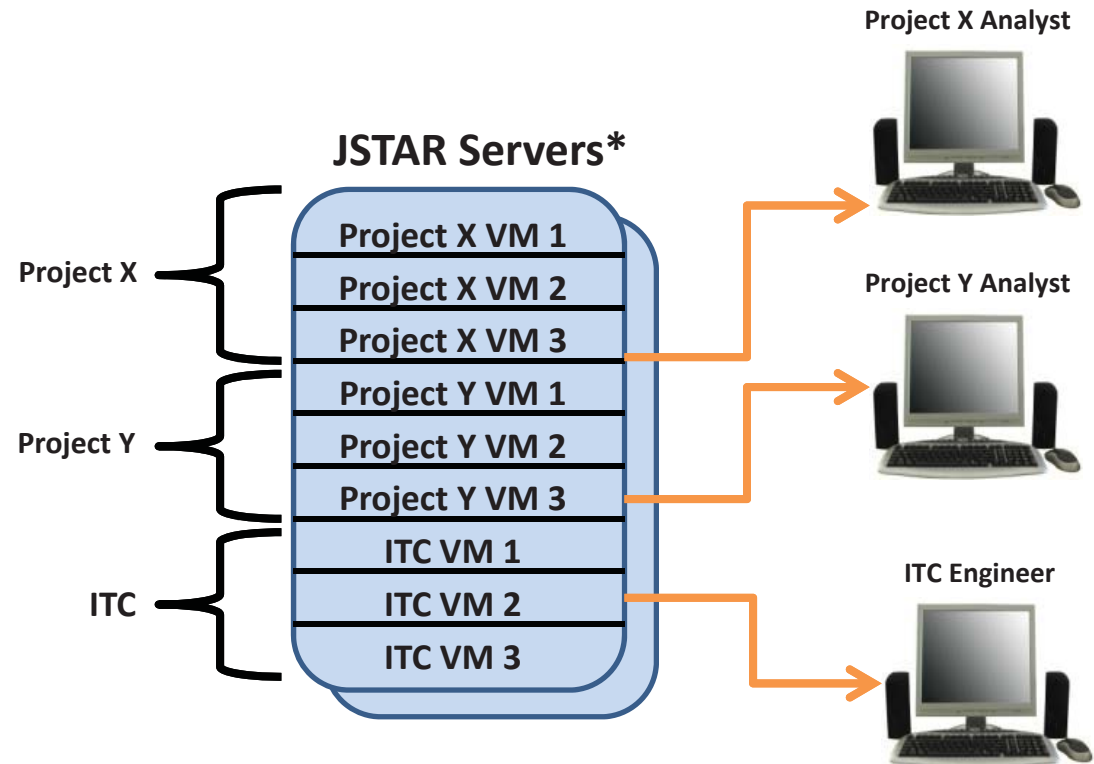
- List maintained on JSTAR Wiki
  - BAE RAD750 6U (contains onboard spacwire and 1553)
  - BAE RAD750 3U (is in Chassis with 1553 and Spacewire cards)
  - BK Precision Power Supply
  - Compact PCI (cPCI) Chassis
  - cPCI Bus Analyzer
  - Gespac 3750 (PowerPC 750)
  - FPGA Development Kits
    - One GR-CPCI-XC4V - [http://www.pender.ch/products\\_cpci\\_xc4v.shtml](http://www.pender.ch/products_cpci_xc4v.shtml)
    - Six GR-XC6S - [http://www.pender.ch/products\\_xc6s.shtml](http://www.pender.ch/products_xc6s.shtml)
  - Logic Analyzer (TLA6402 - <http://www.tek.com/logic-analyzer/tla6400>)
  - MIL-STD-1553 Cards (ExpressCard and cPCI)
  - Oscilloscope (MSO4104B - <http://www.tek.com/oscilloscope/mso4000-dpo4000>)
  - PMC Carrier Card
  - Spacewire Test Set (SWTS)



# JSTAR's Virtualization



The lab utilizes server and desktop virtualization to improve the efficiency and availability of resources and tools. This provides the ability to run multiple virtual machines on each physical machine. Virtualization removes the physical server constraints and enables sharing of resources within the lab.



\* Currently have 9 ESXi server (mostly Dell R720s) but researching VMware's cloud offering.



# Virtualization Features

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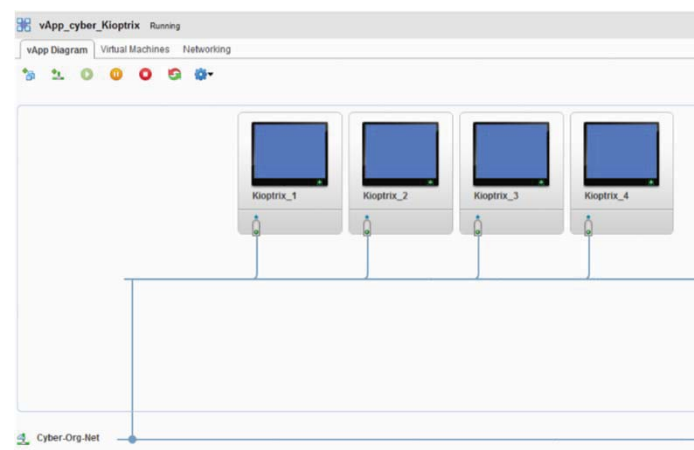
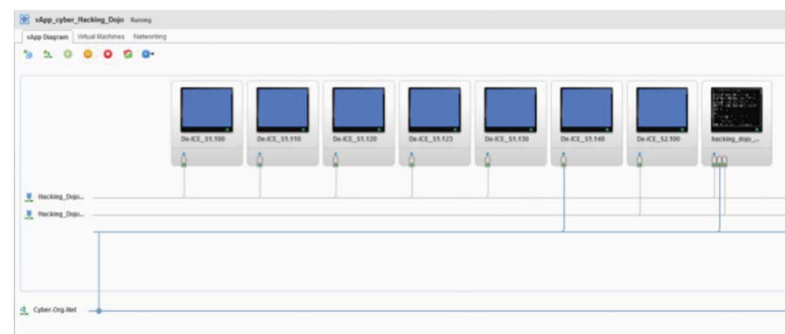
- Virtual Snapshots
    - Can take existing physical machine and convert to virtual machine
      - Easy backup of existing configurations
      - Only need Ethernet connection and administrator password
    - Can convert existing virtual machines (VirtualBox, Parallels, etc.) to VmWare format for use in the lab
  - Cloning/Templates
    - Once a working configuration is completed a clone or template can be created to spawn multiple copies for multiple users
    - Reduces time for configuration management/updating
  - Tool Testing
    - Can provide VMs (Windows, Linux, etc.) to any user to install, checkout, and test new tools
      - Single file delete for Lab Manager once work is complete and VM no longer needed
  - Can virtual separate networks to isolate traffic (Cybersecurity training)
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# Virtualization Benefits w/ Cyber Security



- Due to their risky nature and potential impact to operational systems, cyber security training cannot be performed on live operational systems
  - Therefore, we developed a state-of-the-art training platform using virtualization that provides cyber training exercises using replicated vulnerable systems
  - We are also able to create “virtual” replicas of existing systems and perform training, reconnaissance, and testing against them in a controlled environment with the advantage of if the virtual system gets corrupted it can simply be reloaded with relative ease
- We understand that textbooks and documentation only go so far, and are not able to provide the added benefit gained by actual hands-on experience
  - It is not feasible to offer all personnel their own replicated physical system and it is too risky to offer hands-on cyber training on operational networks; therefore we create each person their own virtual sandbox







# Summary

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- IV&V has 20 year history providing software assurance to NASA
    - Also providing assurance to non-NASA entities
  - JSTAR is a multi-purpose lab
    - Simulation Development
    - HWIL Test Environments
    - Cybersecurity
    - Independent Testing
    - Training
    - ...
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# Contact Information

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**IV&V Website:** <http://www.nasa.gov/centers/ivv/home>

**ITC Website:** <http://www.nasa.gov/centers/ivv/jstar/ITC.html>

**JSTAR Website:** <http://www.nasa.gov/centers/ivv/jstar/JSTAR.html>